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Variation in waterbird populations of two freshwater lakes in Marsabit National Park, northern Kenya

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Northern Kenya is mainly arid and supports a typically dryland avifauna. However a few wetlands also occur in the region which are a strong attraction for resident and migrant waterbirds, being the only stopover sites in a very large area. These sites could therefore be of high conservation value.

In recent years, some of the most important wetlands of central Kenya have been regularly monitored, and the fluctuations of waterbird populations in these areas are now fairly well known (Owino *et al.* 2001, Owino *et al.* 2002). By contrast, very little information is available from northern Kenya. The Lake Turkana area is known to host important waterbird populations (Schekkerman & van Wetten 1987, Bennun & Fasola 1996, Borghesio & Ndang'ang'a 2001), but other sites have never been monitored and no information is available on the size and fluctuations of waterbird populations, nor on the ecological factors that influence them.

In this paper I report the first waterbird counts carried out on two small wetlands in Marsabit National Park, Northern Kenya. I analyse patterns of seasonal variation, and relate the differences between the waterbird communities of the two lakes to the introduction of fish into one of the lakes by humans.

Study area

Marsabit National Park (37°58'E, 02°17'N) protects a vast area of desert, but is mainly known for its forest, which has an area of approximately 120 km^2 and grows on the slopes of an extinguished volcano, at altitudes ranging between 1300 and 1700 m above sea level. The craters of the volcano are occupied by Sokorte Dika and Lake Paradise, two shallow freshwater basins approximately circular in shape (Figure 1). Although somewhat different in size (Table 1), the two lakes are remarkably similar in appearance. Both of them have neither inflows nor outflows and are apparently only fed by rain. The lakes are fringed by expanses (about 10 m wide) of mudflats and have no reedbeds along the shores. Both lakes are regularly visited by large mammals (Elephants *Loxodonta africana* and African Buffalo *Syncerus caffer*) which come to drink. The two lakes are permanent and the water level seems to be fairly constant,

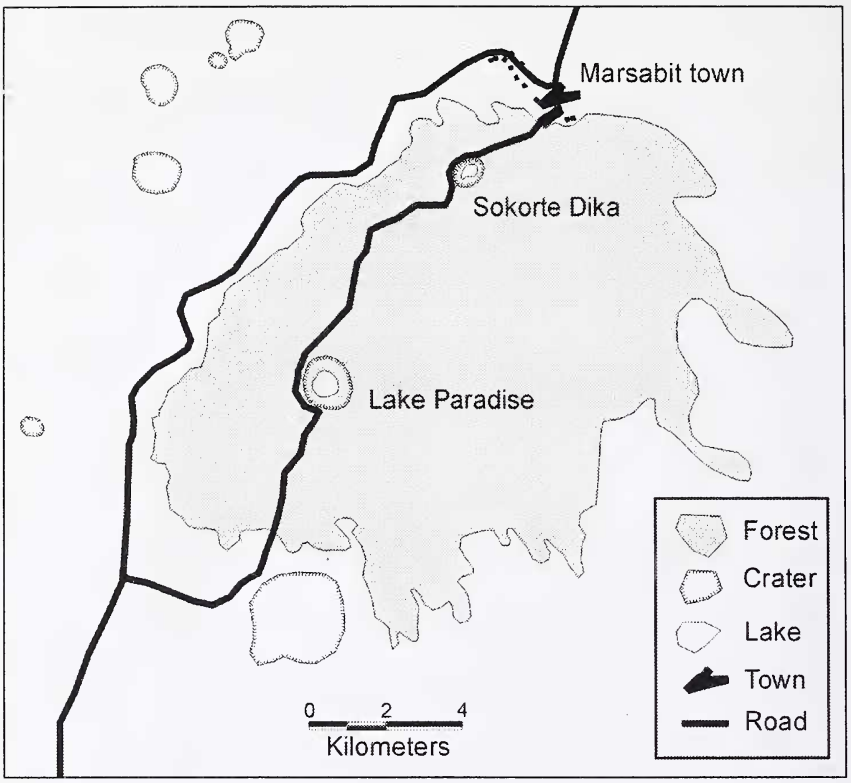

Figure 1. Map of Marsabit forest, showing the position of the two lakes.

Table 1. Size of the two lakes surveyed. Measurements were taken from Landsat satellite imagery of January 1986 (downloaded from http://glcf.umiacs.umd.edu/index.shtml on 15 May 2003).

	Sokorte Dika	Lake Paradise
Main dimensions (km)	0.30x0.50	0.68x0.70
Total water surface (km^2)	0.10	0.36
Perimeter (km)	1.33	2.17

as could be observed during four visits to the area at different times of the year between 1986 and 2002 (pers. obs.).

The most obvious difference between the two lakes is the presence of large quantities of submerged vegetation *(Dichotiledones* spp) in Lake Paradise. These plants appear to be almost absent from Sokorte. However, at Sokorte there are abundant fish, considered to be Nile Tilapia *Oreochromis niloticus*. These fish are not native and, according to local people, were brought to Sokorte from Lake Turkana in the early 1990s. There is no information on why the introduction was made, nor on who did it, although it is likely that the aim was to allow fishing in the lake. However, at the moment, no fishing occurs in the area.

Methods

Waterbirds were counted at Lake Paradise between 7 and 9 March 2000 and again on 30 November and 1 December 2002. Sokorte Dika was counted on 9 and 10 March 2000 and on 5, 6 and 8 December 2002. Since the two lakes are relatively small, the entire length of the shores of one lake could be surveyed in one day, thus two or three complete censuses were available for each lake in both seasons; I used the maximum count of each species as the best estimate of its population in each lake. The same counting technique was adopted during all censuses: walking slowly along the shores and observing birds with 10x40 binoculars.

All waterbird species observed were classified according to their migratory status (African, Palaearctic migrant or having both resident and Palaearctic migrant individuals), feeding zone (open water or close to the shore) and main food source (1=Fish and Amphibians, 2=Invertebrates, 3=Aquatic plants, 4=Terrestrial plants, 5=Omnivorous). Finally, the total bird biomass in each lake was calculated. All the information for these analyses was extracted from published sources (Cramp & Simmons 1977, 1980, 1983, Britton 1980, Brown *et al.* 1982, Urban *et al.* 1986, Maclean 1993, Zimmerman *et al.* 1996). The data were analysed using Chi-squared tests to compare numbers of individuals of different species, feeding and migratory groups between the two lakes and between years. Common and scientific names follow EANHS (1996).

The shores of both lakes were walked thoroughly in December 2002, recording the presence of living fish in the water and the number of dead fish on the shore.

Results

Waterbird community

A total of 34 waterbird species was observed in the two years (Table 2). Twenty-nine species were observed at Lake Paradise, and 17 at Sokorte. Most of the species observed at Sokorte were also seen at Lake Paradise, but three piscivorous species that were only seen at Sokorte (Pink-backed Pelican *Pelecanus rufescens*, Black Stork *Ciconia nigra* and African Darter *Anhinga rufa*) were also new records for the Bird Atlas of Kenya (Lewis & Pomeroy 1989). African residents were always numerically dominant in both lakes and years, and accounted for 78–95% of individuals. Palaearctic migrants were almost completely absent in March 2000 (two individuals in all), but they increased slightly at Lake Paradise in November–December 2002 (87 individuals, 76 of which were ducks).

Waterbird density was always much higher at Lake Paradise than at Sokorte (Table 3). At Lake Paradise, both the number of species and number of individuals increased dramatically in November–December 2002 compared with March 2000 (Table 3). The increase in the number of

Table2. Summary of waterbird counts at Marsabit, March 2000 and November–December 2002. A=African, P=Palaearctic, W=Water, S=Shore, IN=Invertebrates, FI=Fish, AM=Amphibians, TP=Terrestrial plants, AP=Aquatic plants, OM=Omnivore.

Common name	Scientific name	Body mass (g)	Food source	Feeding zone	Migratory status	L. Paradise 2000	L. Paradise 2002	Sokorte Dika 2000	Sokorte Dika 2002
Little Grebe	*Tachybaptus ruficollis*	147	IN	W	A	200	180	2	1
Pink-backed Pelican	*Pelecanus rufescens*	5200	FI, AM	W	A	0	0	1	0
Long-tailed Cormorant	*Phalacrocorax africanus*	577	FI, AM	W	A	1	0	0	0
African Darter	*Anhinga rufa*	1382	FI, AM	W	A	0	0	1	0
Common Squacco Heron	*Ardeola ralloides*	299	FI, AM	S	A, P	0	2	0	0
Great Egret	*Casmerodius albus*	1110	FI, AM	S	A, P	0	2	0	0
Grey Heron	*Ardea cinerea*	1350	FI, AM	S	A, P	1	3	7	0
Black-headed Heron	*Ardea melanocephala*	1135	FI, AM	S	A	5	0	1	0
Hamerkop	*Scopus umbretta*	420	FI, AM	S	A	2	1	0	1
Black Stork	*Ciconia nigra*	3000	FI, AM	S	P	0	0	0	1
African Open-billed Stork	*Anastomus lamelligerus*	1052	IN	S	A	22	12	0	0
Yellow-billed Stork	*Mycteria ibis*	1500	FI, AM	S	A	0	0	6	0
Sacred Ibis	*Threskiornis aethiopicus*	1253	FI, AM	S	A	20	5	6	0
Glossy Ibis	*Plegadis falcinellus*	650	IN	S	P	0	2	0	0
African Spoonbill	*Platalea alba*	1604	IN	S	A	0	1	3	0
White-faced Whistling Duck	*Dendrocygna viduata*	690	TP	S	A	15	2	0	0
White-backed Duck	*Thalassornis leuconotus*	678	AP	W	A	50	43	0	0
Egyptian Goose	*Alopochen aegyptius*	2270	TP	S	A	15	4	20	40
Mallard	*Anas platyrhynchos*	1050	OM	W	P	0	9	0	0
Garganey	*Anas querquedula*	343	OM	W	P	0	10	0	0
Northern Pintail	*Anas acuta*	825	OM	W	P	0	12	0	0
Red-billed Teal	*Anas erythrorhyncha*	568	OM	W	A	15	95	0	0
Hottentot Teal	*Anas hottentota*	243	OM	W	A	15	45	0	0
Northern Shoveler	*Anas clypeata*	600	OM	W	P	0	45	0	0
Southern Pochard	*Netta erythrophthalma*	781	OM	W	A	200	105	0	0
Maccoa Duck	*Oxyura maccoa*	687	IN	W	A	5	2	0	0
Black Kite	*Milvus migrans*	750	FI, AM	W	A, P	5	1	3	0
African Fish Eagle	*Haliaeetus vocifer*	2800	FI, AM	W	A	2	2	1	2
Red-knobbed Coot	*Fulica cristata*	738	AP	W	A	1000	2600	0	1
Black-winged Stilt	*Himantopus himantopus*	168	IN	S	A, P	100	63	0	2
Spur-winged Plover	*Vanellus spinosus*	148	IN	S	A	20	6	0	0
Marsh Sandpiper	*Tringa stagnatilis*	67	IN	S	P	0	1	0	0
Wood Sandpiper	*Tringa glareola*	60	IN	S	P	1	8	0	1
Common Sandpiper	*Actitits hypoleucus*	44	IN	S	P	0	0	1	0

Table 3. Summary of waterbird counts.

	Lake Paradise 2000	Lake Paradise 2002	Sokorte Dika 2000	Sokorte Dika 2002
Feeding categories				
Fish, Amphibians	36	16	26	4
Invertebrates	348	275	6	4
Aquatic vegetation	1050	2643	0	1
Terrestrial vegetation	30	6	20	40
Aquatic omnivore	230	321	0	0
Feeding zone				
Shore	201	112	44	45
Water	1493	3149	8	4
Migratory status				
African	1587	3103	41	45
African & Palaearctic	106	71	10	2
Palaearctic	1	87	1	2
Total number of individuals	1694	3261	52	49
Number of species	20	27	12	8
Density (birds/km^2)	4706	9058	520	490

species in 2002 was mainly due to the presence of Palaearctic migrants in the second year (Table 2), while most of the increase in the number of individuals was due to Red-knobbed Coot *Fulica cristata* (χ^2_1=711, p<0.001). At Sokorte, less species were observed in 2002 (Table 3), but there were no significant changes in the total abundance of waterbirds (χ^2_1=0.1, p>0.05, Table 3).

The proportion of the total number of individuals represented by the five feeding groups differed between the two lakes, both on the shore (χ^2_1=148, p<0.001) and on the open water (χ^2_1=349, p<0.001). On the lake shores, invertebrate-feeders predominated at Lake Paradise, while at Sokorte the most abundant group was the terrestrial herbivores (Figure 2a). In the water, herbivorous species predominated at Lake Paradise, while species eating fish and amphibians accounted for a higher proportion at Sokorte (Figure 2b).

Considering the total biomass (expressed in kg/ha) of the different groups (Figure 3), herbivorous species accounted for most of the biomass at both lakes, but at Lake Paradise aquatic herbivores predominated, while at Sokorte herbivores were mostly terrestrial. Piscivorous species were almost absent at Lake Paradise, but they accounted for a notable proportion of the biomass at Sokorte in both years. Total biomass was much lower at Sokorte than at lake Paradise (Figure 3).

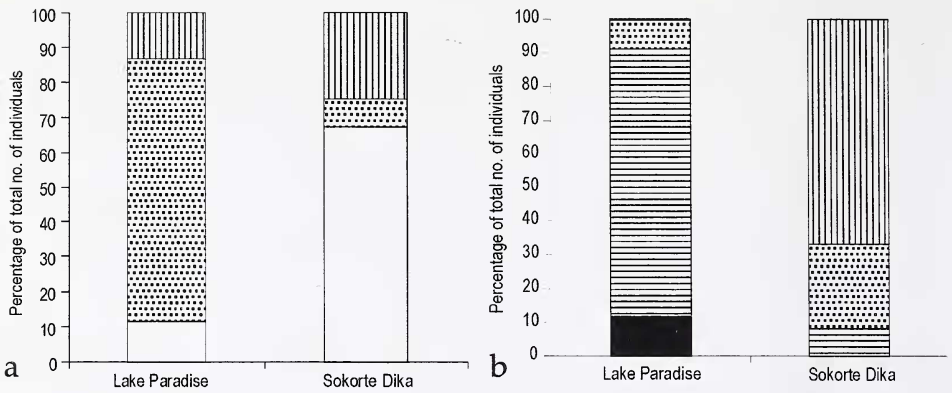

Figure 2a,b. Percentage (over total number of individuals) of different feeding groups censused in a) lake shore and b) open water in the two lakes. Data for 2000 and 2002 censuses are combined. See Figure 4 for key.

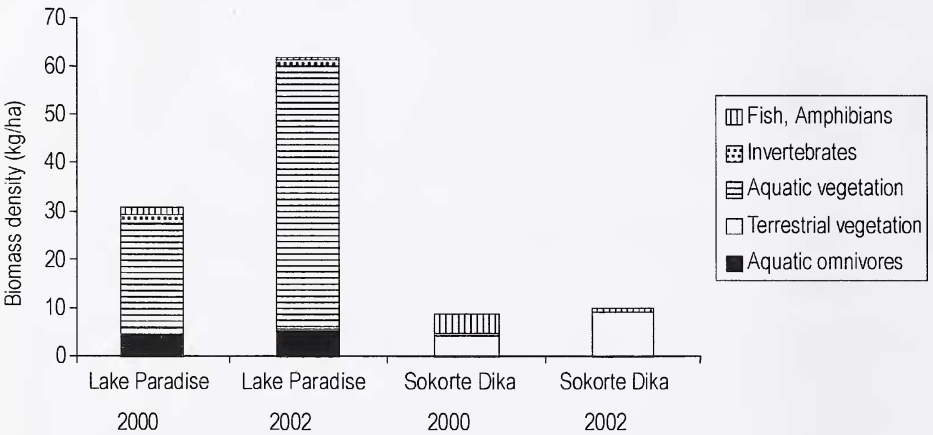

Figure 3. Average total biomass (kg/ha) of waterbird species selecting different food sources.

Fish presence and abundance

No sign of fish presence was noted at Lake Paradise. At Sokorte, fish (Nile Tilapia) were very abundant in the water, although no precise estimates of population density could be obtained, as the waters were very muddy. However, along the shore there were large numbers of dead fish: along a 76 m section of shore 186 corpses (2.4/m) were counted. The average size of dead individuals was estimated as 12.1±2.3 cm (n=17).

Discussion

This article describes the results of the first waterbird counts at Marsabit. Although the presence of most of the species observed in this survey has already been reported in the area in the past (Lewis & Pomeroy 1989), this study showed that some of these little-known water bodies can regularly host large numbers of waterbirds, among which

are regionally-threatened species (White-backed duck *Thalassornis leuconotus*, Maccoa Duck *Oxyura maccoa* and African Darter (Bennun & Njoroge 1996)), and species that have rarely been recorded in Kenya (Mallard *Anas platyrhynchos* (EANHS 1996)). African resident species make up the bulk of the individuals, but the lakes of Marsabit could also be important as a temporary resting area for Palaearctic species during migration. Some of the changes observed between the two years are related to seasonality. In particular, the increase of Palaearctic migrants in 2002 might be due to the fact that in this year counts were made in November–December, that is, after the end of the breeding season in the northern hemisphere, when many migrant species reach Africa for wintering. Palaearctic migrants may well have left the area when the counts in March 2000 were carried out. African species also fluctuated: Red-knobbed Coot was much more abundant in 2002 than in 2000. The causes for this change are not clear, and the present data are not sufficient to answer this question. However, populations of rallidae are known to fluctuate strongly from year to year in other Kenyan Lakes (Owino *et al.* 2002), and thus the pattern found in the lakes of Marsabit does not seem exceptional.

An important result is the demonstration of a striking difference between the fauna of the two survey areas. Lake Paradise had an abundant waterbird community, where aquatic herbivores and invertebrate-feeders dominated. At Sokorte, bird numbers and biomasses were much lower. Here, piscivorous and terrestrial herbivorous species dominated. This difference is best explained by ecological changes brought about by the introduction of tilapia by humans. Nile Tilapia, a very adaptable species with a high reproductive output, is one of the most frequently introduced fishes in freshwater ecosystems, and is often considered a pest in tropical and subtropical areas throughout the world (Ogutu-Ohwayo 1990, Froese & Pauly 2003). It is a herbivore, and can reach very high population densities when predator densities are low (Froese & Pauly 2003).

The evidence gathered in the field suggests that at Sokorte, introduced fish effected large ecosystem shifts, by consuming most of the aquatic plants that probably once lived in the lake (as still found in Lake Paradise). In turn, the disappearance of aquatic plants caused the demise of herbivorous birds. This hypothesis is strengthened by a photograph taken at Sokorte in August 1986 (prior to the introduction of fish). The image (Figure 4) shows that numerous waterbirds (apparently mostly Red-knobbed Coot) frequented the lake at that time. By the year 2000, most herbivorous waterbirds had disappeared: only species such as geese that mainly feed on terrestrial plants persisted. It is also likely that invertebrate populations dropped strongly after the decrease of aquatic plants (due to the lack of shelter and food sources), and this in turn caused the almost complete disappearance of invertebrate-feeding

Figure 4. Lake Sokorte, August 1986. Numerous birds are clearly visible in the water. Most of them appear to be Red-knobbed Coot (L. Borghesio).

birds. By contrast, piscivores increased at Sokorte, although their total biomass had not reach a very high level (Figure 3), presumably because predators, being second-order consumers, cannot sustain biomasses as high as those of herbivores (Krebs 1994).

Another possible effect of the introduction of fish at Sokorte was an increase in bird species diversity, the result of the local waterbird fauna being joined by piscivorous species (Pink-backed Pelican, African Darter, Black Stork), whose presence had not been previously reported in Marsabit according to the Bird Atlas of Kenya (Lewis & Pomeroy 1989). An increase in ecosystem diversity following the introduction of fish has already been found in other Kenyan lakes (Jacobs 1975), but at Sokorte, the small increase of piscivorous species was obtained at the expense of a near total demise of the herbivorous and insectivorous waterbirds (coots, ducks). On the whole, it seems likely that fish at Sokorte had very negative effects on the local ecosystem, causing a strong reduction of bird biomass and a shift in community composition. Should fish be introduced to Lake Paradise as well, which at present appears to be fish free, a similar shift could occur, in which a rich bird community dominated by herbivores and insectivores would be substituted by a small number of mostly piscivorous species. It is important that local Park authorities and game rangers responsible for the protected area are informed about this danger so they can adopt measures to avoid the introduction of fish to Lake Paradise, whose ecosystem is vulnerable to serious damage.

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